

tion of the fronts and air masses is completed, isopleths of specific humidity and of either temperature or potential temperature are drawn. This completes the cross-sectional representation.

The time required in the preparation of such a cross-section is not very great after one has had some experience. By an experienced man the determination of the specific humidities and the potential temperatures, the plotting of all the data, and the complete analysis of the major west-east section can be completed in less than 1½ hours. The smaller north-south sections can be completed in about ¼ hour each. The completion of the three cross sections, when the airplane reports are received from all stations, furnishes one with a rather complete and comprehensive picture of the state of the atmosphere, or the distribution and structure of the air masses and fronts, through the lower 5 km over most of the United States. The usefulness of this cross section in weather forecasting must be obvious to anyone familiar with weather maps. However, the purpose of this paper is only to explain the method of procedure, and not to discuss the results of this work. Extended experience is necessary before such a discussion of results can be satisfactory.

Besides the trouble caused by the frequent delay in the reception of the airplane sounding reports, another unfortunate feature of observations of this kind is that

they are likely to be missing at just the crucial points. Where meteorological action is at a maximum, weather conditions are likely to be such that no flight is made. Consequently on just those days, and in just those regions, where a good cross section would be especially instructive, we are likely to have nothing at all. Since the total number of stations represented on a cross section is very small, the absence of only one or two reports may result in a serious gap in the analysis; and in this type of analysis, just as in that of the surface map, continuity in the analysis from one day to the next is of fundamental importance. This constitutes one serious drawback to the usefulness of the method. It seems as though it should be possible eventually to overcome the present frequent delay in the transmission of the observations; but airplane soundings probably never will be made to an adequate elevation with perfect regularity. However, it is noticeable at the present time that the regularity of the flights, not only at the Army and Navy stations, but also at the Weather Bureau stations, falls far below the high standard set in previous years by such stations as those of the Weather Bureau at Dallas and Omaha. Probably the final solution of this difficulty will be found in the development of cheap and efficient radio-sounding instruments. This improvement would effect not only much greater regularity, but also much greater altitude.

## METEOROLOGY AND CLIMATOLOGY IN A TEACHERS COLLEGE

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The chief purpose of this discussion is to present a brief survey of meteorology as it is taught today in colleges for the preparation of teachers. The material used in this paper has its principal sources in the writer's association with the curriculum building of the course used in the State of Pennsylvania, and in several years of experience in presenting the subject to the students of the State Teachers College at California, Pa. The data used for surveys outside the State of Pennsylvania are credited to W. C. Jacobs of the University of Southern California, who has made a careful survey of instruction in meteorology in the various colleges and universities of the United States.

In the preparation of a course for use in the teachers colleges, the author should attempt to give the student an insight into the physical processes and laws underlying the many different phenomena of weather and climate. The course should be designed primarily to lay a foundation for a more or less detailed study of climate and its relation to man. Since meteorology is admittedly a physical science it would seem most logical for it to be offered in the science departments along with physics and chemistry. In the survey made by Jacobs, it was found that in 46 percent of the cases meteorology was placed in the geography departments; 17 percent in the department of geography and geology; and only 8 percent in the department of physics. In only four colleges was meteorology allotted a department of its own. In the teachers colleges of Pennsylvania no such course has been delegated to the science departments, but it has been placed in the departments where courses in geography are offered.

Since 1930 meteorology has been included in our curriculum under the title of meteorology and climatology. In most teachers colleges, meteorology finds a place as a correlated subject with geography. In Penn-

sylvania it has been offered as an introduction to the study of the climates of the world, because the basic or fundamental principles set forth in meteorology serve well as an introduction to a systematic study of climatology. In offering the combined course of meteorology and climatology it has been found reasonably satisfactory to introduce the meteorological part with the physics and chemistry of the air. By this is meant the physical characteristics of the air and its chemical composition, and their variations. No attempt should be made to introduce the technical phases of the subject. Enough should be presented to challenge thought and to give a clearer and better approach to the study of climate.

Many students who elect this course have not had training adequate to pursue the more technical discussions of meteorology. In many instances the writer has known students who did not take a course in meteorology because they felt they had not had sufficient prerequisites for the work. That might be one of the reasons why so few have seriously considered courses in the field of meteorology. In a survey of 737 students enrolled in a teachers college it was found that all had had a course in general science during their high-school training. Of these, 262 had had at least 1 course in physics; and 487, or over one-half, a course in chemistry. It is interesting to notice the relatively small percentage who had a course in physics. It is not uncommon to hear a student who has the opportunity to pursue a course in meteorology say, "I can't take that, for I have not had enough work in physics and chemistry."

In the teachers college of Pennsylvania a course in meteorology and climatology is offered as a free elective for any student or as an elective for students who elect geography as one of their majors. In the survey made by Jacobs it was found that of the 252 courses offered, over one-half could be placed in the two major groups

of meteorology proper and climatology. The former represented 38 percent of the number of courses and the latter 33 percent. The rest belonged to miscellaneous or combination courses.

The course as prescribed by the State syllabi is defined as follows: Meteorology and climatology consists of a systematic study of physics of the air and a description of the different climatic regions of the earth. It sets up a number of objectives consistent with the above definition, which are briefly as follows:

1. To learn the fundamental physical aspects of the atmosphere, basic for an understanding of climate.
2. To acquire a working knowledge of the principles of climatology.
3. To develop skill in the reading of climatic maps and graphs.
4. To understand the importance of daily weather and climatic conditions to individuals.
5. To become aware of the climatic conditions under which we live.
6. To acquire sufficient knowledge to correctly interpret natural adaptations of animal and plant life.

The meteorological portion of the work is emphasized in the first part of the course under the following main topics: (1) The solar system; (2) the earth as a part of the solar system; (3) the atmosphere.

The major part of the time is given to the study of the atmosphere, which is divided into four main topics: (1) Composition; (2) pressure; (3) temperature; (4) precipitation and humidity.

The composition of the air serves to introduce the study of the atmosphere. Attention is given to the percentages of the different gases which compose the air at different altitudes.

Since our study has in mind man and his activities, it is obvious that a course in meteorology should attempt to point out as far as possible the physiological effects of the atmosphere. Also, variations in the composition of the atmosphere excite human response, nor can any man escape their influences. Indeed in many parts of our own country the populace is extremely concerned about the composition of the atmosphere, especially as regards dust, water vapor (humidity), gases, etc. Furthermore, when so much is being said today about the effects of solar radiation, it seems advisable to emphasize the screening effects that the atmosphere has upon the light rays from the sun.

Temperature and pressure must receive considerable attention, for they are basic in the study of climate. Thermometers and barometers are studied as to kinds and uses; and in as many instances as possible, the laboratory is used to demonstrate the various instruments. Most colleges do not have what would be considered adequate equipment to properly teach the subject, since the viewpoint of special schools today is toward professionalism. No teachers college can attempt to teach a professional course in meteorology and climatology, but many can offer enough to help the student acquire a

better understanding of climate and climatic responses. Enough is included in the Pennsylvania course on temperature and pressure to produce a clear understanding of the circulation of the atmosphere. Every teacher of geography and general science finds it necessary to have an understanding of the principles of air movements in order to teach about the wind belts of the earth and their effects. Much of the more technical phases of air movements is not needed in a course for the average teacher, for so much of it is of no practical use to him. Concrete problems and exercises should be used in connection with the study of pressure and temperature.

After a study of barometers, as to kinds and uses, attention is given to the representation of pressure on maps and charts. Isobaric surfaces and pressure slopes are introduced and studied. Insofar as possible, the pressure gradient is considered in respect to its influence on wind velocities.

Weather maps showing isobars for annual, seasonal, and daily periods of time are used freely. It has been found that there are certain graphic publications which include data for preparing maps and graphs, and which, when used by the student, serve well to acquaint him with the various pressure belts of the world. The wind belts of the world are considered in respect to their origin, the areas over which they occur, and their effects upon man.

Precipitation and humidity demand thoughtful consideration as prerequisites to the study of the different climates of the world. Special attention is given to the control of humidity. The various methods and instruments used in determining humidity are, as far as possible, at the disposal of the members of the class. Some time is given to the study of clouds and fogs in their relation to precipitation and sunshine. They are intimately associated with radiation and are in part control factors of temperature, and help to determine the environment of man. Dews and frosts are discussed sufficiently to show that they are important enough to command some attention.

The brief course in meteorology serves to introduce a study of the climates of the world. The early part of the course in climatology is used to present the distinct basic types of climates, together with the recognized standard classifications due to (1) Supan, (2) Köppen, (3) Herbertson, (4) Jones and Whittlesey, etc. Each classification is considered with respect to its basis for the climatic divisions. In the State of Pennsylvania it seems the Jones and Whittlesey classification is the one most frequently chosen for a detailed study. Each division of this classification is considered separately. Maps, temperature graphs, rainfall graphs, etc., are made and studied. The responses in each case are given special consideration, even to the preparation of product maps and compilation of various data. The writer has found it profitable to require the making of certain climatic maps from data furnished by the Government of the United States or by the governments of the various States.